5.5 Uniform Fields and Voltage

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Parallel Plates

Electric field between parallel plates is the same everywhere.

- so a charge in field experiences the same F_E everywhere between.
- as charge moves toward "like" plate, work is done $W = \vec{F}d = E_p$ gained

$$\underset{\text{pot. diff.}}{\Delta V} = \frac{\overset{\text{pot energy}}{\Delta E_p}}{Q_t} = \frac{W}{Q_t} = \left(\frac{\vec{F}}{Q_t}\right)d$$

but $\vec{E} = \left(\frac{\vec{F}}{Q_t}\right)$ ... substitute and now $\Delta V = \vec{E}d$

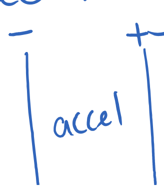
rearrange $\boxed{\vec{E} = \frac{\Delta V}{d}}$ (d = distance between the plates)

units: $\left[\frac{V}{m}\right] = \frac{\frac{J}{C}}{m} = \frac{\frac{N \cdot m}{C}}{m} = \left[\frac{N}{C}\right]$ ← original units for Electric field are equivalent to $\left[\frac{V}{m}\right]$

($V = \frac{E_p}{Q}$, $W = Fd$)

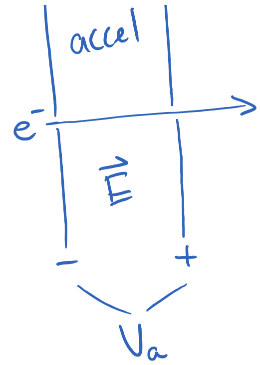
Cathode Ray Tube – accelerates and deflects beam of e^- which then display on fluorescent screen.

Accelerating Voltage



$$V_a = \frac{E_k}{Q_e} = \frac{\frac{1}{2}mv^2}{Q_e}$$

(m = mass of e^-, v = max velocity of e^-, Q_e = charge of e^-)

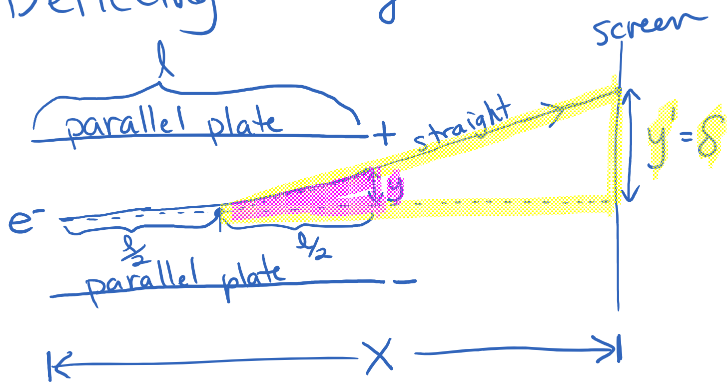


V_a - Q_e ... Q_e

accelerating voltage — V_a

Q_e — charge of e^-

Deflecting Voltage



- e^- path bends between plates then continues straight
- if extend line back after going straight, it itersects the e^- path half-way thru the deflecting plates $\left(\frac{l}{2}\right)$

$$\vec{E} = \frac{\Delta V_\delta}{d}$$

ΔV_δ — deflecting voltage

d — distance between plates

Amount of deflection as leaving δ plates:

$$y = \frac{1}{2} a t^2$$
$$= \frac{1}{2}\left(\frac{F}{m}\right) t^2$$
$$y = \frac{1}{2}\left(\frac{\vec{E} Q_e}{m}\right) t^2$$

Amount of deflection on screen: (similar triangles)

$$\frac{y'}{y} = \frac{\left(x - \frac{l}{2}\right)}{\frac{l}{2}}$$

$$\delta \rightarrow y' = \frac{y\left(x - \frac{l}{2}\right)}{\frac{l}{2}}$$

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In general

- more V_a (voltage) → more speed (v)
- more speed → less deflection → $\frac{y_1}{y_2} = \frac{V_{a2}}{V_{a1}}$

- more V_δ → more deflection → $\frac{y_1}{y_2} = \frac{V_{\delta 1}}{V_{\delta 2}}$

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